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(71) Applicant *(for all designated States except US):* TELEVERKET [SE/SE]; S-123 86 Farsta (SE).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)* : STJERNHOLM, Paul [SE/SE]; Telia Research AB, S-136 80 Haninge (SE).

(74) Agent: KARLSSON, Berne; Telia Research AB, S-136 80 Haninge (SE).

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(54) Title: METHOD FOR ESTIMATING C/I DENSITY AND INTERFERENCE PROBABILITY IN THE UPLINK

(57) Abstract

The invention relates to a method for estimating the C/I density and interference probability in the uplink. According to the invention, two or more base stations synchronously measure signal strength and signal identity in the uplink in their own and each other's channels. By measuring over a sufficiently long time, a statistical basis for how the signal strengths from mobiles connected to a respective base station are distributed is obtained. From the basis, density functions for the signal strength from traffic to its own and, respectively, another station can be formed. Due to the synchronous measuring method, the functions can be normalised and a C/I or C/I + N density function can be formed, from which the interference probability can be calculated.

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TITLE OF THE INVENTION: METHOD FOR ESTIMATING C/I DENSITY AND INTERFERENCE PROBABILITY IN THE UPLINK

FIELD OF THE INVENTION

The present invention relates to a method for calculating, by means of signal strength measurements in the uplink, how the traffic connected to a base station interferes with traffic connected to another base station. The method provides curves for C/I (carrier/interference) density and the interference probability can be calculated by this means.

PRIOR ART

For an operator of a mobile telephone network and the like, it is of interest to know the interference characteristics in the network. Having knowledge about the probability of interference, the operator can plan the capacity and quality of the network. It has previously been known to measure the signal strength in the downlink, that is to say measuring the signal strength from base station to mobile. Interference can be easily calculated from the coverage measurements taken when the signal strength has been measured from actual base stations.

However, it has been more difficult to estimate the interference in the uplink since it is caused by a fleet of mobiles which are continuously moving and where the position of an individual mobile station is unknown.

SUMMARY OF THE INVENTION

The present invention provides a method for estimating the C/I density and interference probability in the uplink, which method solves the abovementioned problem.

According to the invention, base stations synchronously measure signal strength and signal identity from mobiles on their own and each other's channels to

form a statistical basis for how the signal strengths from mobiles connected to a respective base station are distributed. A density function (C) for the signal strength from traffic in the direction of its own base station and a density function (I) for the signal strength of traffic in the direction of another base station are formed from the basis. From these density functions, a density function for C/I can then be formed and the probability of interference calculated.

Other embodiments of the invention are specified in greater detail in the subsequent Patent Claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in detail with reference to the attached drawings, in which:

Figure 1 is a diagrammatic figure of the measuring method according to the present invention,

Figure 2 shows an example of a C density curve obtained,

Figure 3 shows an example of an I density curve obtained,

Figure 4 is a combination of the curves C and I to illustrate the calculation of the C/I density, and

Figure 5 is an example of a calculated C/I density curve.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

As mentioned earlier, the method according to the invention is based on synchronous measurement of the signal strength in the uplink. The measuring method is shown diagrammatically in Figure 1. The method is described for two base stations but can also be applied in the case where more than two base stations are included. Two base stations A, B thus measure the signal strength and signal identity from traffic in their own and each other's channels. A mobile which is connected to base station A generates a signal strength C at base station A and a signal strength I at base station B and vice versa for a mobile station within the area of base

station B. By measuring over a sufficiently long time, a statistical basis is obtained for how the signal strengths from mobiles connected to a respective base station are distributed.

From the measured data, a number of measurement results per signal strength and channel can be obtained. The measurement result in their own channels, after normalisation with respect to the number of measurement results in their own channels, provides a density function for the signal strength from traffic in the direction of its own base. An example of such a curve is shown in Figure 2.

The measurement results on the channels of the second base station B normally only generate the upper part, "the tail", of the signal strength distribution from the traffic of the base since most of the signal strengths are below the noise level of the measurement equipment. Figure 2 shows an example of a curve for interfering traffic I. The shape of the curve is thus only known down to a limit which is marked by 0 in the Figure. To obtain a correct density curve, a normalisation must be carried out with respect to the total traffic. Since the measurement is carried out synchronously at both base stations A and B, the total interfering traffic I is known since this is also measured by station B synchronously with A. By normalising the signal strength tail with the traffic in their own channels measured by station B, the density function for the part of the curve above the noise level 0 is thus obtained. It normally does not matter that the total signal strength density is not known since it is only the strong signal strengths, that is to say "the tail" which produces interference.

From the abovementioned curves, the C/I density can be calculated. To illustrate this, both curves have been drawn in the same diagram in Figure 4. Since the signal strength densities of their own and respectively the interfering base traffic $p_C(x)$ and, respectively, $p_I(x)$ are independent, the C/I density $p_{C/I}(x)$ for $x = \Delta C/I$

in the Figure can be calculated as

$$p_{C/I}(\Delta C/I) = \sum_{k=-\infty}^{\infty} p_I(k-\Delta C/I)p_C(k)$$

where k represents the signal strength in dB.

For each ΔC/I, a probability is obtained, which can be plotted in a new density curve for C/I. An example of such a curve is shown in Figure 5. From this, the probability of interference being caused, that is to say that C/I is less than a specific value, can be calculated as

$$p_{C/I}(k \le C/I_{max}) = \sum_{k=-\infty}^{C/I_{max}} p_{C/I}(k)$$

The curve is not known for a ΔC/I greater than a given value Δ_{max} since there is the abovementioned limit for small values in the I curve above. However, this has no significance since this part of the curve provides large values of ΔC/I and therefore low interference.

Conditional probabilities can also be calculated on the basis of the measured data. In calculating the interference probability, the traffic handling per base station, channel or channel group and variations with time can also be taken into consideration.

Special attention must be paid when the measurement is carried out on base stations which utilise the same channels since in this case only the common-channel interference can be measured when their own traffic is not carried in the channel.

The synchronous measuring method according to the present invention thus provides a novel tool for planning and operation of a mobile telephone network or the like. The invention is only limited by the Patent Claims below.

PATENT CLAIMS

1. Method for estimating the C/I density, characterised in that base stations synchronously measure signal strength and signal identity from mobiles in their own and each other's channels,

that a statistical basis is obtained for how the signal strengths from mobiles connected to a respective base station are distributed,

that a density function (C) for the signal strength from traffic in the direction of its own base station is formed from the basis,

that a density function (I) for the signal strength from traffic towards another base station (B) is formed from the basis, and

that a density function for C/I is formed by using the abovementioned density functions.

2. Method according to Claim 1, characterised in that a density function (I+N) for signal strength from traffic towards another base station (B) plus noise interference is formed from the basis, and that a density function for C/I+N is formed by using the abovementioned density functions (C) and (I+N).

3. Method according to Claim 1 or 2, characterised in that the I density function and, respectively, the I+N density function is normalised by using the measurement result of the respective other base station's (B) measurement of its own traffic.

4. Method according to Claim 1 or 2, characterised in that the lowest signal strength value of the I density curve is placed above the noise level in the measuring equipment.

5. Method according to any of the preceding claims, characterised in that the interference probability is calculated by integrating the C/I or C/I+N density function.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 93/00574

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: H04B 7/26, H04Q 7/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: H04B, H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP, A1, 0458768 (TELEFONAKTIEBOLAGET L M ERICSSON), 27 November 1991 (27.11.91), page 3, line 18 - page 7, line 2, claim 1 --	1-5
Y	Patent Abstracts of Japan, Vol 14,No 170, E-913, abstract of JP, A, 2-26420 (NEC CORP), 29 January 1990 (29.01.90) --	1
Y	WO, A1, 9010342 (TELEVERKET), 7 Sept 1990 (07.09.90), page 5, line 10 - page 10, line 34 --	1-5

[X] Further documents are listed in the continuation of Box C.   [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
17 November 1993	24 -11- 1993
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB, A, 2234142 (NEC CORPORATION), 23 January 1991 (23.01.91), page 2, line 11 - page 3, line 5, claim 4	1-5

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INTERNATIONAL SEARCH REPORT
Information on patent family members

01/10/93

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